33RD INTERNATIONAL COSMIC RAY CONFERENCE, RIO DE JANEIRO 2013
THE ASTROPARTICLE PHYSICS CONFERENCE

The trigger system of DAMPE

GUO JIANHUA [1,2], ZHANG YUNLONG[3], FENG CHANGQING[3], ZANG JINGJING[1,2], HU YIMING[1,2], CHANG JIN[1,2]

[1] *Purple Mountain Observatory, Chinese Academy of Sciences*
[2] *Key Laboratory of Dark Matter and Space Astronomy , Chinese Academy of Sciences 2010DP173032*
[3] *University of Science and Technology of China*

jhguo@pmo.ac.cn

Abstract: The Chinese high energy cosmic ray detector in space, named DAMPE(DArk Matter Particle Explorer), is a high energy cosmic ray explorer with the goal of searching dark matter by measuring the spectrum of electron and gamma ray. The energy range of the detector will cover 5GeV-10TeV for electron. The detector consists of four sub-detectors: Plastic Scintillation detector, Silicon-Tungsten tracker, BGO calorimeter and neutron detector. In this paper, we will introduce the trigger system for DAMPE, which will extremely suppress the proton background and get an acceptable trigger rate.

Keywords: High energy cosmic ray detector, DAMPE, trigger

1 Introduction

In recent years, several experiments such as ATIC [1], Pamela [2], FERMI-LAT [3], AMS-02 [4], have reported some abnormity in high energy electron and positron spectrum. All the results may indicate there are nearby sources of electron and positron. To understand the characteristic of the spectrum bump, the DAMPE(DArk Matter Particle Explorer) in space is proposed by Purple Mountain Observatory in China [5]. The goal of the detector is to measure the energy spectrum of high energy electron and gamma ray with high resolution and high background rejection.

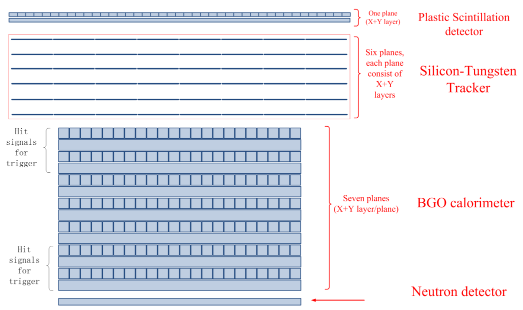

Figure 1: scheme of DAMPE

2 Architecture of DAMPE

DAMPE is an high energy cosmic ray detector, which consists of PSD (plastic scintillation detector) , STK(Silicon-Tungsten tracker), BGO calorimeter and Neutron detector, as shown in Figure1. The energy range will cover 5GeV-10TeV for electron and gamma ray. The plastic scintillation detector is implemented by 82 pieces of 884mm*28mm*10mm plastic scintillation bars. It is composed of X,Y direction belts. The Silicon-Tungsten tracker has 192 micro-strip silicon ladders. There are 6 planes of detector, which also consist of X,Y direction layers for angular measurement. The angular resolution of STK is about 0.2^o @5GeV.

The BGO calorimeter is made of 7 planes of BGO crystal bars, which are also composed of X,Y belts. Each BGO crystal is 25mm*25mm*600mm size.

The Neutron detector is plastic scintillation detector with Boron.

The plastic scintillation detector and BGO crystals are both read out by PMT (photo-multiplier tube). Because of the large dynamic range of BGO detector which is about 10^5, the BGO detector use three different dynodes signal of PMT to measure the light from BGO.

3 Data acquisition system

In DAMPE, the electronics of detector includes FEE (front-end electronics) and PDPU (Payload Data Process Unit) for data acquisition. The main task of PDPU system is to decode the command from satellite and collect data of FEE to mass memory. Figure2 is the data flow of DAMPE.

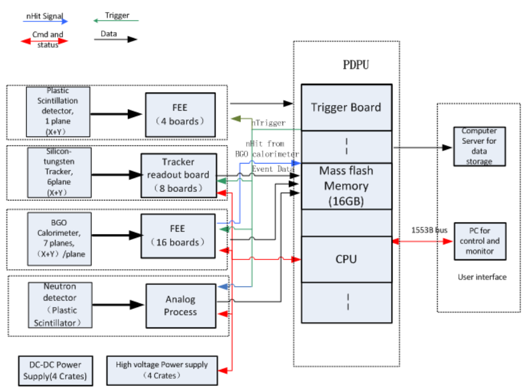

Figure 2: data flow of DAMPE

When a high energy particle hits the detector, the pre-amplifier of FEE will integrate the charge signal from detector and wait for trigger signal. If it is a good event, trigger system will send a trigger signal to FEE and PDPU system. As soon as FEE receive the trigger, they will hold the peak of the shaping signal in the slow shaper of FEE and begin to digitalize it. Before the event data are sent to the

PDPU, the trigger system will disable the new trigger. The timing is shown in Figure3.

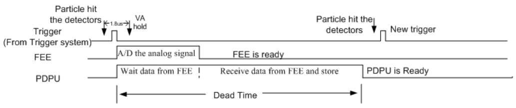

Figure 3: timing of DAQ

The PDPU consists of a high performance LEON3 CPU and 16GB mass memoy. We use high speed LVDS link for event data and UART for slow control. The data speed between FEE and PDPU is 20Mbps and the UART is 115200bps.

4 The trigger system

The BGO calorimeter consists of 7 planes. Each plane is including X/Y BGO layers. So there are 14 layers of BGO bars in DAMPE. From top to bottom, the layer1-layer4 and layer11-layer14 will generate hit signals, which are sent to trigger board. The trigger board uses a FPGA (field programmable gate array) to implement the coincidence logic for the hit signals. The trigger system is shown in Figure 4.

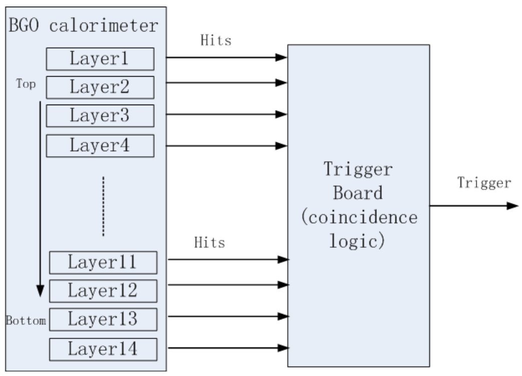

Figure 4: trigger system in DAMPE

In DAMPE, the trigger board is located in PDPU, which is responsible for distributing the trigger signal to the FEEs of the detector. The FEEs use the trigger signal as a timing reference to hold the peak of the shaping signals, which are linear to the energy deposited in the detector. The trigger distribution is shown in Figure 5

There are two running mode for DAMPE in orbit: dedicated calibration mode and observatory mode. In dedicated calibration mode, the DAMPE can be set to sample the pedestal of detector, calibrate the linearity of electronics' response with known the stimuli or measure the MIPs deposited in the detector. In observatory mode, the DAMPE is concerned to the high energy electron and gamma ray.

When the DAMPE sample the pedestal or calibrate the linearity of the electronics, the trigger system use the counter to generate the periodic trigger with 40MHz system clock.

When the DAMPE measure the MIPs or high energy particle, the trigger system will use the hit signals from BGO calorimeter and generate trigger signal with coincidence logic.

Figure 6 and Figure 7 is the schematic of the logic for MIP and high energy electron. The estimated trigger rate is

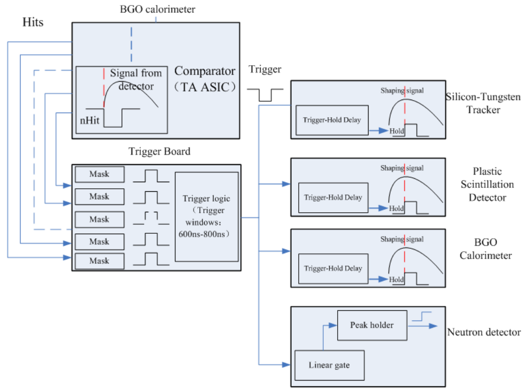

Figure 5: trigger distribution in DAMPE

about 50Hz in observatory mode for high energy electron and gamma ray.

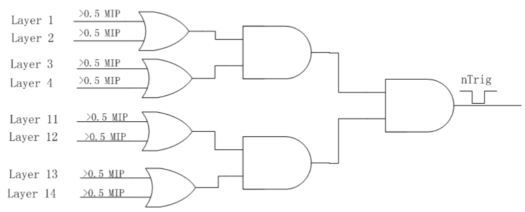

Figure 6: coincidence logic for MIPs

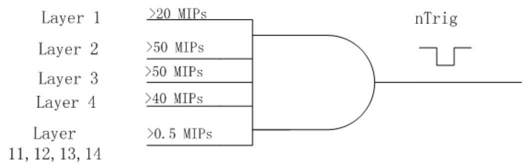

Figure 7: coincidence logic for high energy electron and gamma ray

5 Summary

We have finished the prototype of DAMPE in September 2012. In October 2012, we shipped the prototype to CERN for beam test. We used the electron beam, which was between 5GeV to 290GeV, to measure the energy response of the DAMPE. The result showed that the DAMPE worked well as expected.

Acknowledgment: This work was funded by the National Natural Science Foundation of China (NSFC) under Nos. 11003051,11273070 and 11203090. It was also supported by the Strategic Priority Research Program on Space Science, the Chinese Academy of Sciences under No. XDA04040202.

References

[1] J. Chang, J. H. Adams Jr, H. S. Ahn et al. Nature, 2008, V.456, P.362 C 365
[2] O. Adriani, et al., Nature, 2009, Volume 458, Issue 7238, pp. 607-609
[3] M. Ackermann et al., Phys. Rev. Lett. 108, 011103 (2012).
[4] M. Aguilar et al., Phys. Rev. Lett. 110, 141102 (2013)
[5] Jian Wu: 2013, PROCEEDINGS OF THE 33st ICRC